

# Pump-probe experiments on three-dimensional silicon-based inverse opals

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Three-dimensional photonic band gap materials are interesting candidates for ultrafast optical switching based on, e. g., the optical Kerr effect. The latter originates from the real part of the third-order nonlinear optical response. We present nonlinear optical experiments on three-dimensional very high-quality silicon inverse opals fabricated by chemical vapor deposition. Linear transmission spectra and an SEM image of the sample are shown below (LHS). The pronounced transmission minimum at  $2.2\mu\text{m}$  corresponds to the first photonic stop gap in [111] direction. In our pump-probe experiments, we use two optical parametric oscillators (OPA) that can be tuned independently in the near-infrared, both pumped by a regeneratively amplified Ti:sapphire laser system (Spectra-Physics Hurricane). For excitation well below the a-Si mobility edge and in a transmission geometry, we find a large induced absorption on the order of  $10^4\text{ cm}^{-1}$  with a recombination time of about 1-2 picoseconds (RHS). Notably, we do neither find significant instantaneous components nor any particular spectral resonances at the photonic stop band edges for any combination of probe and pump wavelength (not shown). This behavior can obviously not be explained by the optical Kerr effect. In simple model calculations we can qualitatively reproduce the observations by two-photon-absorption followed by a Drude-like behavior of the excited carriers with extremely short damping time. In other words: the imaginary part of the nonlinear optical response dominates its real part. Thus it should be included in corresponding theoretical calculations, which has not been done so far to the best of our knowledge.

